Mega-Sweep 111A

KAY ELECTRIC COMPANY

OPERATION
AND MAINTENANCE MANUAL

ISSUE C

Mega-Sweep 111A

KAY ELECTRIC COMPANY
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WAVEMETER SETTINGS

UHF OPERATION Set wavemeter at.....divisions.

VHF OPERATION Set wavemeter at.....divisions.

Serial #.....

Figure 1, **111-A MEGA-SWEEP**

SECTION I
GENERAL DESCRIPTION

A. APPLICATION.

The **MODEL 111-A MEGA-SWEEP** is a wide range sweeping oscillator which provides a frequency modulated signal with adjustable center frequency. In conjunction with an oscilloscope, it may be used to obtain a pictorial indication of the frequency response characteristics of amplifiers, filters, oscillators and similar circuits.

B. FEATURES.

The **MODEL 111-A MEGA-SWEEP** is a beat frequency oscillator, employing two X-band klystrons as the two beating oscillators. Only by employing oscillators operating at this very high frequency (about 9000 Mc) can the wide output frequency range of the **111-A** be covered. The two oscillator outputs are conducted by a waveguide assembly to a silicon crystal detector or mixer, and the beat between them is used as the output frequency. One of the klystrons, called the variable oscillator or VO, has its center frequency made variable by a tuning dial mechanism so as to produce an adjustable output frequency. It is also swept by applying a sawtooth sweep wave to its repeller. The other klystron, called the fixed oscillator or FO, is operated at either of two fixed frequencies to produce the two output frequency ranges of the **111-A**. The FO has a blanking wave applied to its repeller to produce a zero base line on the oscilloscope presentation. A tunable, cavity type, absorption wavemeter is coupled into the waveguide ahead of the crystal mixer. The resonant frequency of the cavity is adjustable by means of a micrometer head.

Two matching transformers are available to transform the 70 ohm unbalanced output of the **MEGA-SWEEP** to a 300 ohm balanced output.

1. UHF - *Ultra-Former*, 450-900 Mc.
2. VHF - *Model 12 Transformer*, 50-220 Mc.

C. SPECIFICATIONS.

Frequency Range: 10 to 950 Mc in two ranges.
- *a. VHF Range* - 10 to 500 Mc.
- *b. UHF Range* - 400 to 950 Mc.

Sweep Width: Up to 40 Mc in two ranges.
- *a. Narrow Range* - 1 to 15 Mc.
- *b. Wide Range* - 10 to 40 Mc.

Sweep Rate: Approx. 50 to 100 cps. A 60 cps synchronizing voltage is introduced to permit locking to the line frequency.

Sweep Voltage: Regular sawtooth approx. 20V.

RF Output Impedance: 70 ohms, nominal.

RF Output Voltage:
- *a.* 150 millivolts into a 70 ohm load at the **HIGH** connector.
- *b.* **ATTENUATOR** control has a range of about 26 db.

Dial Accuracy: ±10% approximately. Using wavemeter permits accuracy to ±(1% +5 mc).

Power Input: 105 to 125 volts, 50 to 60 cps, 110 watts.

Dimensions: 10½" x 14½" x 18½".

Weight: 37 lbs.

Accessory Equipment Available: *Ultra-Former* used for UHF band. *Transformer Model 12* used for VHF band. They are matching transformers used to transform the 70 ohm unbalanced output to a 300 ohm balanced output.

D. EQUIPMENT SUPPLIED.

1. **111-A MEGA-SWEEP.**
2. Instruction Book.

SECTION II
INSTALLATION

A. GENERAL.

The **MODEL 111-A MEGA-SWEEP** is designed for table-top operation and thus presents no special installation problems. However, to insure optimum operation, the equipment should not be subjected to excessive moisture, vibration, or temperature conditions. The installation should also include provisions for connection to an oscilloscope, to the circuit under test, and to a 110 watt source of 117V (±10%), 50 to 60 cps, a-c power.

B. INTERCONNECTION DATA.

1. OSCILLOSCOPE CONNECTIONS. The oscilloscope used should have a flat frequency response from 30 to at least 20,000 cps. The vertical gain should be approximately 0.5V per inch. For stage by stage measurements higher gain is desirable.

Connect the SWEEP OUTput terminals directly to the horizontal axis input terminals of the oscilloscope.

2. RF CONNECTIONS TO TEST CIRCUITS.

Before the RF output of the **MEGA-SWEEP** *is used, a good connection should be established between the chassis under test and the* **MEGA-SWEEP.** *This precaution is partial protection against damaging the crystal. In any case, it is good practice to provide ground connections between all units.*

RF connection of the output of the **MEGA-SWEEP** to a receiver is achieved by a length of cable which is included with the instrument. The shield of the cable should be grounded near the point at which the center conductor is connected. For use in the frequency range above 15 Mc, a 100$\mu\mu$f mica or ceramic condenser should be used in series with the center conductor of the cable. This protects the crystal from damage in case the center conductor of the cable accidentally comes in contact with 6.3 heater voltage or other voltages which would burn out the crystal. The output cable should be terminated in 75 ohms, either by the input of the circuit under test or by matching pads.

3. MARKER CONNECTIONS. The **MEGA-SWEEP** can be used with the *Kay Utilator* to produce a birdie marker on an oscilloscope display. The standard *Utilator*, with its high RF output, will give a birdie over the 4.5 to 220 Mc range. Any signal generator may be used to produce a birdie display providing the correct levels are obtainable.

4. MEGA-SWEEP TO TV RECEIVER CONNECTIONS. For IF alignment, a tube shield connected to the center conductor of the coaxial cable may be employed. This method utilizes the capacity of the shield can to the mixer plate to feed the IF amplifier.

When the signal is to be fed to a receiver having a balanced input circuit, some form of balun network is required. For the UHF band between 450 and 950 Mc, the *Ultraformer* (not furnished with the 111-A) may be used. For the VHF television bands, a lower-frequency matching transformer (not furnished as a part of the 111-A) can be obtained from the Kay Electric Company. This unit transforms the 70 ohm unbalanced output to a 300 ohm balanced, with very little loss of voltage, so that the balanced output voltage is twice the output of the **111-A.** The VSWR will not exceed about 1.3 over the band. For those applications where low VSWR is of prime importance and the lower output voltage can be tolerated, resistive balun networks may be employed.

5. PULSE MODULATION OF THE MEGA-SWEEP WITH THE MEGA-PULSER.

a. General: The *Mega-Pulser* provides output pulses 0.025, 0.05, 0.1 and 0.25 microseconds wide at repetition rates of 100, 1000 and 2000 pps. Positive or negative pulses of 100 volts amplitude are available at a 50 ohm level.

In testing the transient response of wide band RF amplifiers, an RF carrier which can be keyed on and off by a train of pulses is required. The frequency of the RF carrier should be tunable so as to permit adjustment to a frequency within the pass band of the amplifier to be tested. A method of obtaining a pulse modulated carrier by use of the **MEGA-SWEEP** and the *Mega-Pulser* is described below.

b. Procedure. Remove the cover of the klystron box. Remove the cap connector clip of klystron *V-4*. Connect a 100K resistor between this connector and the repeller cap of the klystron.

Connect a 10 db coaxial pad into the output of the *Mega-Pulser*, Terminate the cable with two Allen-Bradley resistors in series which total approximately 51 ohms. 15 to 20 volts output should be obtained at the series point of the resistors.

Connect the output of the cable between the cap of klystron *V-4* and ground, using a 0.01μf blocking condenser. Caution should be taken to make lead lengths as short as possible.

c. Operation. After the **MEGA-SWEEP** has been turned on and warmed up for five minutes, set the **SWEEP WIDTH** to zero. Adjust the **MEGA-SWEEP** as outlined in Section III.

Turn the **FO PEAKING ADJust** so as to decrease the negative voltage on the repeller until the klystron just ceases to operate. This is done by depressing the **PUSH** switch and observing meter *M-1*. Measure the resultant change in repeller voltage with a VTVM. The pulse amplitude should be adjusted to approximate this value.

Energize the *Mega-Pulser* with the polarity switch set to give a negative pulse. Set the desired pulse width and repetition rate.

The output of the **MEGA-SWEEP** should now be a pulse modulated carrier at the frequency of the **MEGA-SWEEP**. The amplitude can be varied by the use of the attenuator. Slight readjustment of the **VO PEAKING ADJust** control may be necessary to obtain the RF frequency desired.

6. **USE OF EXTERNAL SWEEP VOLTAGES.** High frequency external sweep voltages can be applied to the sweeping oscillator by use of the following connections:

a. Remove the shield cover of the klystrons; remove the repeller cap connection of klystron *V-5*. Connect a 100K resistor between the repeller cap and the connector that has been removed.

b. Connect the output of the sweep voltage source through a 0.01μf blocking condenser to the repeller. Approximately 20 volts peak to peak is needed.

c. Rotate the **SWEEP WIDTH** control counterclockwise.

d. Connect the **SWEEP OUTput** terminals directly to the horizontal axis input terminals of the oscilloscope.

The above method will give sweeps with frequency relationships reversed from the conventional one in which frequency increases from left to right along the scope trace. If it is desired to remedy this condition, two courses are open:

1. The sweep voltage can be applied to the repeller of the FO, *V-4* instead of *V-5*. Only relatively narrow sweeps can be had without excessive amplitude modulation.

2. The external sweep voltage can be phase-reversed by passing it through the internal sweep-amplifier tube *V-2*. This will require circuit changes which must take proper account of the coupling, D-C level, and overload characteristics of the amplifier stage, and will be limited in usefulness by the relatively narrow-band characteristics of the stage. Also, if very low-speed sweeps are desired, it will be necessary to increase the time constant of the coupling circuits.

SECTION III
OPERATION

A. IDENTIFICATION OF CONTROLS.

1. SWEEP OUTput Jack *(J-1)*. These terminals bring out the 60-cps linear sawtooth sweep voltage which is used as a horizontal deflection signal for the oscilloscope. They are normally connected directly to the horizontal (X-axis) input of the oscilloscope.

2. SWEEP RATE Control *(R-3)*. This potentiometer provides a means of varying the repetition rate of the sawtooth voltage. For normal operation, the sawtooth sweep rate is "locked-in" at the nominal 60-cps line frequency. However for special tests, such as hum measurement, the repetition rate may be varied above or below 60-cps.

3. SWEEP WIDTH Control *(R-23)*. This front panel control, located below the SWEEP RATE control, varies the amount of sawtooth voltage applied to the repeller of *V-5*, the variable klystron oscillator.

4. Sweep Switch *(S-2)*. This three-position rotary wafer switch allows the operator to select one of three types of operation.

a. On the WIDE SWEEP position, there is about 10 Mc of sweep on the FO and an adjustable 0 to 30 Mc on the VO for a total of 10 to 40 Mc.

b. On the SWEEP NARrow position, there is a small residual of about 1 Mc on the FO, which with the adjustable 0 to 14 Mc on the VO gives a total of 1 to 15 Mc.

c. On the NO BLanking position, there is essentially zero sweep on the FO so that the total sweep is 0 to 14 Mc; all sweeps are active, and there is no baseline on the scope presentation.

5. PEAKING ADJust VARiable OSCillator *(R-33)*. This potentiometer, located to the right of the output meter, adjusts the B- voltage applied to the repeller of the variable klystron oscillator *(V-5)*. This control is used to select the correct mode of klystron operation.

6. PEAKING ADJust FIXED OSCillator *(R-26)*. This potentiometer adjusts the B- voltage applied to the fixed frequency oscillator *(V-4)*. This control is used to select the correct mode of klystron operation.

7. FIXED OSCillator TUNER. This control is coupled to the tuning struts of the fixed klystron oscillator *(V-4)*. It adjusts the size of the resonating cavity and therefore the output frequency. A clockwise rotation of this control will reduce the size of the cavity and increase the output frequency to enable the klystron to operate in the UHF band. A counterclockwise rotation of this control will reduce the frequency and the klystron will operate in the VHF range. In normal operation this control should be rotated in the desired direction until the mechanical stops are reached. Any inbetween step will cause the klystron to operate at the wrong frequency.

8. Variable Oscillator Tuner. This control is coupled to the variable klystron oscillator and through a set of gears to the coarse frequency control. This tuning control adjusts the size of the resonating cavity and therefore the output frequency. A counterclockwise rotation of this control increases the frequency.

9. FREQUENCY METER. This wavemeter is of the absorption type and measures the output frequency by tuning a resonant cavity until it absorbs maximum energy from the waveguide of the MEGA-SWEEP. Multiplying the reading of this meter by a conversion factor will give the true output frequency.

10. Sweeping Output ATTENUATION Control *(R-42)*. This variable carbon card attenuator is located inside the waveguide and in its maximum position attenuates the oscillator output by 26 db.

11. Oscillator Output Jacks *(J-2 & J-3)*. These coaxial connectors deliver the final output of the sweeping oscillators. Connection to the LOW OUTPUT jack provides 26 db of attenuation. This output is normally fed directly to the circuit under test.

12. Power Switch *(S-1)*. This toggle switch, located in the lower right hand corner of the front panel, controls all a-c and d-c power in the **MEGA-SWEEP**. When this switch is in the **ON** position, the adjacent red light comes on indicating that all filament and B circuits have been energized.

13. PUSH Switch *(S-3)*. In the energized position this toggle switch removes the negative voltage from the repeller of the variable oscillator and shorts out *R-36* making the meter more sensitive.

NOTE: The following internal potentiometers are factory-adjusted and normally should not be changed unless necessitated by component replacement or serious misalignment of the equipment.

14. Shape Control *(R-30)*. This control is used to establish the tracking of the variable oscillator's repeller voltage. It acts to keep the klystron in the correct mode of operation.

15. Slope Control *(R-31)*. This control, located above the klystrons, is used in conjunction with the shape control *(R-30)* to adjust the mode of operation.

16. Blanking Control *(R-25)*. This control adjusts the amount of square wave blanking information applied to the repeller of the fixed klystron oscillator *(V-4)*.

17. Internal Sweep Width Control *(R-11)*. This potentiometer, located next to the 12AX7 sweep amplifier, adjusts the amount of sawtooth voltage applied to the variable klystron oscillator and thereby adjusts the width of the sweep output. The control is properly adjusted when the maximum sweep width is between 40 and 50 Mcs.

B. OPERATING PROCEDURE

Low Band Operation (1 to 500 Mc.)

1. Plug the power cord into a source of 117 volts, 50 to 60 cps a-c. Operate the power switch to **ON**, and note whether the pilot lamp lights. Allow one to two minutes for the tubes to reach a stable operating condition.

2. To establish operation at VHF frequencies (10-500 Mc), turn the FIXED OSCillator TUNER control counterclockwise until a stop is engaged. This is a light mechanical stop, and undue pressure should not be applied.

3. Adjust the VARiable OSCillator PEAKING ADJust for maximum deflection of the crystal current meter on the panel. It should be 90 to 100 microamperes.

4. Set SWEEP switch at NO BLanking, ATTENUATION at minimum (fully counterclockwise). Operate PUSH switch to right, and hold. Adjust FIXED OSCillator PEAKING ADJust to maximum panel meter reading. It should be 30 to 50 microamperes.

5. Release the PUSH switch and set the variable oscillator to the same frequency as the fixed oscillator by either of the two methods below:

Method A - using wavemeter only.

Set SWEEP switch at NARROW and SWEEP WIDTH control at 0. Adjust tuning dial until the meter dip due to the tuning of the FREQUENCY METER comes at the same scale reading as for the FIXED OSCillator. It may be necessary to readjust the VARiable OSCillator PEAKING ADJust.

Method B - using an oscilloscope (recommended).

The scope is to be swept using the voltage which appears at the SWEEP OUTput terminals of the **111-A**. Connect the vertical input terminals either directly to the HIGH OUTPUT connector of the **111-A**, or preferably, to the HIGH OUTPUT through a detector box so that the rectified envelope may be viewed. Set SWEEP switch at WIDE and SWEEP WIDTH control at 40. Adjust the tuning dial until the region of zero-beat locking is placed in the center of the sweep. Adjust the PEAKING controls for maximum output.

6. Note whether the tuning dial reads 0 on its scale. If not, adjust the drive until it does.

7. If it should become necessary to adjust the tracking of the swept-frequency oscillator, the VARiable OSCillator PEAKING ADJust control can be shifted slightly with the frequency reading dial set at 400.

The complete tracking operation for the VARiable OSCillator is as follows:

a. Set dial at 400 and adjust **VAR OSC PEAKING ADJ** for maximum microammeter reading or for maximum RF output.

b. Set dial at 700, adjust internal slope potentiometer and maximize as above.

c. Set dial at 900, adjust internal shape potentiometer and maximize as above.

d. Repeat above procedure, touching up where necessary.

8. The instrument is now working properly in its low frequency range, 10 to 500 Mc. Connect to the device to be tested and set the tuning dial in the center of the pass band. Adjust the **SWEEP** switch and the **SWEEP WIDTH** control for an appropriate width of swept band.

9. When peaked as directed above, the RF output voltage will be about 0.1 to 0.25 volt. Lower voltages are obtained by turning the **ATTENUATOR** control clockwise; a reduction of a maximum of 26 db is obtained. A fixed reduction of 26 db is obtained by shifting the output cable to the **LOW** connector. The two adjustments together cover a range of 52 db below 0.1 volt.

10. If the scope picture appears unsteady, adjust the **SWEEP RATE** control. The sweep oscillator will lock to the power line frequency in about mid-range of this control, and a steady trace will be obtained.

High Band Operation (400 to 1000 Mc.)

Before attempting to adjust the **111-A** to operate in its high frequency range, the procedures in 1 thru 10 above must be followed. This puts the variable oscillator in its correct operating frequency range. The variable oscillator adjustments must thereafter not be altered, since this oscillator must operate in exactly the same frequency range for both high and low output frequency bands.

11. To establish operation at UHF frequencies (400-950 Mc), turn the **FIXED OSCillator TUNER** clockwise until a stop is engaged. The **PEAKING ADJust FIXED OSCillator** will have to be readjusted to maximize the output. The crystal current shown on the panel meter should be 30 to 50 microamperes.

12. With the tuning dial set at 0, recheck the frequency of the variable oscillator. It should be at the higher of the two recorded scale readings listed in Section I, Specifications. There is a 400 Mc difference between these two readings so the fixed oscillator is now operating exactly 400 Mc lower in frequency than it was on the low range, and the tuning dial now reads on its higher scale, 400 to 950 Mc.

13. The sweep circuits and output controls are used in the same manner as in the low band.

SECTION IV
THEORY OF OPERATION

A. GENERAL.

The **MEGA-SWEEP MODEL 111-A** is a beat-frequency oscillator with two X-Band klystrons as the two beating oscillators. Only by employing oscillators operating at this very high frequency (about 9000 Mc) can the wide output frequency range of the **111-A** be covered. The two oscillator outputs are conducted by a waveguide assembly to a silicon crystal detector or mixer, and the beat between them is used as the output frequency. One of the klystrons, called the variable oscillator or VO, has its center frequency made variable by a tuning dial mechanism so as to produce an adjustable output frequency. It is also swept by applying a sawtooth sweep wave to its repeller. The other klystron, called the fixed oscillator or FO, is operated at either of two fixed frequencies to produce the two output frequency ranges of the **111-A**. The FO has a blanking wave applied to its repeller to stop oscillation on each alternate sweep, thus producing a zero base line on the oscilloscope presentation.

As is usual in beat frequency generators, the VO is coupled more tightly to the mixer than is the FO, so that the variations which occur in its output when it is adjusted or swept will have less effect on the output amplitude. The output amplitude is controlled by adjusting the amount of the smaller signal from the FO which gets to the mixer. This is done by a carbon-card attenuator inserted in the waveguide assembly so that it controls the output of the FO.

A tunable cavity type absorption wavemeter is coupled into the waveguide ahead of the crystal mixer. The resonant frequency of the cavity is adjustable by means of a micrometer head which tunes the cavity for a dip in the oscillator output, as indicated either by a decrease in the crystal current meter or by a dip in the output curve when this is viewed on a scope. When using the meter as an indicator, the weaker FO can only be measured if the stronger VO is disabled to remove its signal from the crystal. The scope method is more convenient since the disabling is not required; the two oscillators produce different, easily distinguishable reactions on the scope picture.

The difference between the two **FREQUENCY METER** scale readings for the two oscillators, when multiplied by the proper factor, gives the output beat frequency in megacycles.

Figure 2 is a block diagram of the **MEGA-SWEEP** showing its more important elements. The fixed frequency klystron A is mounted so that its output probe inserts into waveguide L. The energy from this tube is attenuated by the variable attenuator J. Energy from the variable frequency klystron B is coupled into waveguide H. Waveguides L and H are coupled together by means of directional coupler K. The wavemeter G is coupled into waveguide H and the frequency difference between the two oscillators is detected by silicon crystal F. Sawtooth sweep voltage from relaxation sweep generator D is connected to the variable frequency klystron B and to the sweep voltage output post. The regulated power supply E supplies current for oscillators A, B, and D. The microammeter M reads the DC current component in the crystal output. A circuit C is provided for disabling the variable frequency klystron B so that the activity of each klystron (A and B) can be indicated separately on the microammeter M.

B. THE KLYSTRON OSCILLATORS.

This subsection deals with the theory of operation, characteristics, and frequency ranges of two klystron beating oscillators, but only in so far as the use of the instrument is concerned. The fundamental theory of klystron oscillators should be obtained from references such as "Electronic Measurements" by Terman and Pettit, p 521–530, or "Radar Systems and Components" by Bell System authors, p 488–761, published by D. Van Nostrand Co., New York, 1949. Internal adjustments and servicing operations, such as resetting of the dial mechanism, calibration of dial scales, and tracking of the repeller voltage, are covered in Section V.

1. **CIRCUIT DETAILS.** The two beating oscillators A and B in *Figure 2* are indicated schematically as *V-4* and *V-5* on *Figure 8*. These are 723 A/B type reflex klystrons. The positive 300 volt regulated supply is used as an accelerating voltage for these tubes. The cathode is grounded, and since the cavity is electrically connected to the outside envelope of the tube, it is 300 volts above ground. Insulated tuning drive connections and a protective cover over the tubes are used to protect the circuit and the user; a pilot lamp is included in the +300 volt lead to serve as a fuse in the event of a short-circuit.

The negative 300 volts regulated supply is used to deliver the repeller potentials to the two klystrons through a resistance network which permits adjustment of the voltage from the panel by the user and causes the voltage to vary automatically as the dial mechanism is operated, thus keeping the voltage approximately at the correct value for maximum output. Small variations from perfect tracking are compensated for by means of the panel controls. These adjustments are required since the frequency and amplitude of oscillation are determined by the repeller voltage at any given cavity setting. This characteristic is illustrated in *Figure 4*, where frequency and amplitude of oscillation are plotted vs. repeller voltage for a typical klystron. It will be understood that the center frequency of each frequency vs. repeller voltage curve is varied by changing dimensions of the cavity. In addition, the repeller voltage required for maximum oscillator amplitude varies with cavity setting. Normally, the adjustment of repeller voltage is made so as to obtain maximum output. Since the change of repeller voltage also affects frequency, it is usually necessary to readjust the cavity setting slightly after making the repeller (**PEAKING**) adjustment, in order to regain the desired center frequency.

2. **FREQUENCY RELATIONSHIPS.**

Never operate the tuning dial over more than its calibrated range. Doing so may make a complete dial recalibration necessary.

The VO is always *higher* in frequency than the FO, and because of this the FO will be found at lower scale readings on the **FREQUENCY METER**. On the low range, 10 to 500 Mc, the FO operates in about the middle of the tuning range of its own cavity mechanism and that of the **FREQUENCY METER**; that is, about 1000 on the **FREQUENCY METER** scale. The VO tunes from this frequency upward, to about 2000 on the **FREQUENCY METER** scale, giving a beat range of 0 (actually 10) to 500 or 600 Mc. On the 400 to 950 Mc range, the VO stays in the same place, but the FO is moved down to the low end of the **FREQUENCY METER** scale, near 00. The actual settings for the two positions of the FO are determined for each pair of klystrons and are recorded on the inside front cover of this book. New numbers should be substituted whenever a klystron replacement is made. The method of determining the correct settings is detailed in the Maintenance Section.

3. **SETTING KLYSTRON FREQUENCY.** By this, we mean the placing of each klystron at that frequency which will make the tuning dial read correctly in output frequency over its entire calibrated range. There is only one point (that of zero beat) that can be established unambiguously without the use of any additional equipment, and that of course is of value only on the low range and is not usable on the high range where the two oscillators never come closer that 400 Mc to each other. Furthermore, even on the low range, use of the zero-beat reference point alone will not insure correct dial calibration throughout the range for the calibration is not linear. Therefore it is necessary on both ranges to make use of a frequency standard, either the self-contained **FREQUENCY METER** or some type of external marker generator. The use of the **FREQUENCY METER** will be outlined here;

The wavemeter can be used with either the self-contained crystal current meter to indicate resonance, or with an external oscilloscope. Using the crystal current, the sharpest indications will be obtained when neither oscillator is swept. Therefore, set the **SWEEP** switch at **NO BL** and the **SWEEP WIDTH** control at 0. To measure the frequency of the VO, rotate the micrometer head of the **FREQUENCY METER** until there is a sharp decrease of crystal current, and read the scale when the wavemeter is set at the lowest point of the dip. To measure the frequency of the FO, the procedure is the same except that the **PUSH** switch on the panel must be operated and held operated to disable the VO and remove its larger crystal current contribution from the meter circuit. Simultaneously with the disabling of the VO, the **PUSH** switch increases the sensitivity of the meter by a factor of two so as to give better indications of the relatively smaller current due to the FO.

When using the oscilloscope as an indicator, it is best to use a wide sweep; set the **SWEEP** switch at **WIDE** and the **SWEEP WIDTH** control at maximum. Then, when the wavemeter is tuned through the frequency of the VO, a fairly sharp dip will be seen to move along the pattern. The scale reading is taken with the dip at the center of the pattern. When the wavemeter is tuned through the FO frequency, a much broader dip will be seen, since the

frequency of this oscillator is being swept much less than that of the VO. With the **SWEEP** switch on **NARROW**, or **NO BL**, the sweep is removed from the FO, and the whole trace will dip at once. Since these reactions come through any amplifier or other network which the **111-A** is being used to test, this method of measurement will be found simple and convenient to use, requiring no circuit or setup changes to be made when a frequency check is desired.

Since the output beat frequency is the difference of the frequencies of the two oscillators, its value is obtained by multiplying the difference of the two **FREQUENCY METER** scale readings by the proper factor. For rough measurements this can be taken as 0.5 Mc per small division. For a more accurate determination, account must be taken of the fact that the calibration curve of the wavemeter is not quite linear.

To find the micrometer head calibration correction factor:

a. Determine the resonant points of the variable oscillator and the fixed oscillator as outlined in Section IV, B-3. Note the micrometer head reading for each oscillator and determine the difference between the two by subtracting the fixed oscillator reading from the variable oscillator reading.

b. Locate this value on the divisions scale of the correction factor graph, *figure 10*. From the point where this value intercepts the appropriate (VHF or UHF) plot, read the correction factor on the vertical scale of the graph.

c. The true output frequency may now be obtained by multiplying the micrometer head difference divisions value, obtained in step *a*, by the correction factor obtained in step *b*.

C. WAVE GUIDE.

The outputs from the two oscillators A and B of *Figure 2* are coupled into the two waveguide sections L and H through probes. Section L contains the carbon card variable attenuator J and a carbon card matching device N. This latter card terminates section L so that a minimum of energy is reflected. Energy from section L is coupled through directional coupler K into waveguide section H. Energy from oscillator B is coupled through a probe into waveguide section H. This section contains a buffer resistance card I which isolates oscillator B from the output load. Waveguide section H is terminated by crystal mixer assembly F. Wavemeter G is also coupled into section H.

The directional coupler K attenuates the energy from section L reaching section H so that the mixer F receives much less energy from oscillator A than from oscillator B. Since B is swept in frequency its amplitude varies (see *Fig. 4*). The amplitude from A does not vary since the frequency is fixed. In any heterodyne process, if one signal is much smaller than the other, it controls the amplitude of the difference frequency output. Consequently, because of the attenuation resulting from the directional coupler K, and the consequent reduction in level of the amplitude of signal from A, modulation of the **MEGA-SWEEP** while sweeping is small.

The directional coupler K by virtue of its directivity attenuates to a great degree any energy transfer from A to B and thus isolates the two oscillators from each other. This minimizes "pulling" when they are near the same frequency.

D. WAVEMETER.

An absorption type adjustable cavity wavemeter (G in *Fig. 2*) is coupled into waveguide H by means of a probe. At the resonant frequency of the cavity, energy is absorbed from the waveguide and prevented from reaching detector F. This causes the meter M to indicate a current dip. The wavemeter is tuned by a plunger whose position is adjusted by a micrometer head. By successive readings on the two beat frequency oscillators a reading which is proportional to output frequency can be obtained.

E. OUTPUT SYSTEM.

The RF output system (refer to schematic, *Fig. 8*) consists of crystal *D-1* and its mounting, output connectors *J-2* and *J-3*, *R-39* and *R-40*. The indication of the d-c component in the crystal *D-1* output is accomplished by the circuit including *R-36*, *R-37*, *R-38*, *C-12*, *S-3* and *M-1*.

The crystal *D-1* acts as a detector and picks up energy from the waveguide. *D-1* is supported in a chuck. The position of this chuck is adjusted

for the best match between the crystal load and the waveguide. A choke surrounds the chuck forming a bypass for the microwave frequency components of the two beat frequency oscillators. The **HIGH** output is taken directly from *D-1*. *R-39* and *R-40* form a voltage divider producing a signal voltage ratio of approximately 20 to 1 between the **HIGH** and **LOW** outputs. The impedance level at each output connector is a nominal 70 ohms.

R-37 and *C-12* comprise a low pass filter for passing the d-c component of crystal current to meter *M-1*. With switch *S-3* in the normal position, the negative voltage from *R-33* and sweep voltage from *R-23* are connected to the repeller of *V-5*, allowing it to operate. The sensitivity of *M-1* is decreased by *R-36*. Since the energy reaching crystal *D-1* from *V-5* is much greater than that from *V-4*, meter *M-1* reads essentially the d-c component from *V-5*. With *S-3* operated, *V-5* is rendered inoperative by the removal of voltage from the repeller electrode; and the sensitivity of meter *M-1* is increased by shorting *R-36*. In this position *M-1* reads the d-c component of crystal current resulting from the output of *V-4* only.

F. SWEEP CIRCUITS.

1. **SWEEP GENERATOR.** The **MEGA-SWEEP** uses a 2D21 thyratron relaxation oscillator, adjustable over the range of about 50 to 100 cps by means of a panel control marked **SWEEP RATE**. A small amount of voltage from the a-c heater supply is injected into the grid circuit of this oscillator so that when its natural frequency is adjusted close to the line frequency, locking will occur. A positive-going sawtooth voltage of about 100 volts peak is generated by the slow charging and rapid discharging of the sweep capacitor *C-1*.

2. **SWEEP PHASE-INVERTER.** About one-third of the output voltage wave of the sweep generator is impressed on the grid of the cathode-follower tube *V-2* by means of a potential divider network. A positive-going replica of the input appears in the cathode and this is connected to the **SWEEP OUTput** terminals on the panel, for use in driving external oscilloscope sweeps. A phase-inverted (negative-going) sawtooth wave appears at the plate of *V-2* across the internal potentiometer *R-11*. By adjustment of this potentiometer, that amount of sweep voltage required to produce 15 Mc on the **NARROW** range and 40 Mc on the **WIDE** sweep range can easily be set. The selected amount of sweep voltage output is applied across the whole of potentiometer *R-23*, the **SWEEP WIDTH** control. Almost all klystrons are capable of being swept over more than the nominal range of the **111-A**, though not usually with satisfactory uniformity of amplitude. It is possible, therefore, to obtain wider sweeps by readjustment of the internal sweep control, *R-11*, provided the non-uniform output can be tolerated. Some improvement in uniformity of output is usually obtained by operating at lower output levels, with the **ATTENUATION** control partly screwed in. This increases the ratio of amplitudes of the two oscillators at the mixer and tends to reduce output amplitude effects due to variation of the VO over the swept band. When attempting to get wide sweeps, full advantage should be taken of the effect of adjustments of the fixed repeller voltages, as set by the panel **PEAKING** controls. Careful adjustment of these voltages will often improve the linearity of output amplitude. Also, the various repeller modes usually differ somewhat in their sensitivity to sweeping and in their flatness of output.

3. **BLANKING CIRCUIT.** Blanking of the trace is accomplished by operating the FO in an oscillating condition for one complete frequency sweep, then shifting its repeller voltage suddenly to a value outside of the oscillating region for the next sweep. During the blanked sweep the VO oscillates and sweeps as usual, but there is no beat-frequency output. The required half-frequency square wave is generated in a conventional scale-of-two circuit employing a 12AU7 tube, *V-3*, triggered by the differentiated output of the sweep generator, *V-1*. The plates of *V-3* swing over a range of about 100 volts when the scale-of-two turns over, and the desired blanking amplitude of about 25 volts is selected from a tap on the plate resistor of one of the tubes.

Now, if this square wave were fed to the repeller of the FO by d-c coupling or through an RC circuit of sufficiently long time constant, it would arrive at the repeller as a true square wave; the repeller would be held at a constant potential during the on-time and the FO would not change its frequency. But, if the time constant were made smaller so that the repeller voltage changed during the on-time due to the "droop" of the top of the wave, the FO frequency would change (sweep) during the on-time. On one side of the blanking wave, the change would subtract from the

VO sweep, while on the other side it would add and produce a greater overall sweep of the output beat. The user has the problem of selecting the correct side of the blanking wave so that the sweeps add, for this is necessary to obtain wide sweeps and make the calibration of the panel **SWEEP WIDTH** control correct. Merely adjusting the d-c component of repeller voltage can cause oscillation on either side of the wave, and since the range of the panel repeller voltage control marked **PEAKING ADJ** has been made great enough to cover at least two, and sometimes three, separate repeller modes, there will be several points at which output will be obtained, half of them right and the others wrong. Considering any given pair, more closely spaced than the others, the correct one is the one with the lower scale reading (the more counterclockwise). However, to help the user to avoid ambiguity and arrive at the correct adjustment, another feature has been added – a circuit, which cuts off the blanking wave and at the same time adds a small d-c component of repeller voltage equal to half the amplitude of the blanking wave. Its polarity is chosen so that if the **FO PEAKING ADJ** is made with the circuit in the unblanked condition (**SWEEP** switch set at **NO BL**) and then the switch is thrown to either of the blanked sweep positions (**SWEEP** switch at **WIDE** or **NAR**) the repeller voltage is automatically set over so that the correct side of the blanking wave is chosen and the sweeps will add.

This circuit has an additional value: when correctly adjusted, the center frequency of the sweep does not change when switching from blanked to unblanked sweeps. This avoids having to readjust the **PEAKING ADJ** when switching. An internally adjusted potentiometer is provided to permit setting the increment of d-c voltage exactly correct.

SECTION V
SERVICE & MAINTENANCE

A. LOW OUTPUT SIGNAL.

Decrease of RF output signal from the sweeping oscillator is in most cases accompanied by a decrease in d-c current indication on the panel meter.

1. If low RF output is noted, the procedure outlined in Section III-B, (Oscillator Peaking) should first be undertaken. If the panel meter indication is low or equal to zero, with peaking switch both in normal and in depressed position, a weak crystal is usually indicated. Remove crystal as indicated below, test as indicated below, and replace, if defective.

2. If panel meter indication is low or equal to zero with panel switch depressed, but normal with switch released, a defective FO klystron is indicated.

3. If panel meter indication is low or equal to zero with panel switch released, but normal with switch depressed, a defective VO klystron is indicated.

4. Reversing the klystrons to determine whether the current indications follow the tubes will indicate whether the tubes or the associated circuits are at fault. Be sure to switch off power before touching the klystrons.

B. VOLTAGE MEASUREMENT.

Typical d-c voltage values which appear at various circuit points in the sweeping oscillator are shown on *Figure 8*. Two important voltages are +300 and -300 which are applied to the klystrons. These voltages may be measured by removing the shield top at the right rear of the panel. A d-c voltmeter (at least 20,000 ohms per volt) can then be used to measure the positive voltage between the klystron cavity nut and ground. This voltage should equal +300. A screwdriver control on the power supply to the rear of the cabinet can be used to readjust this voltage. The negative 300 volt supply can be checked indirectly for proper operation by use of the same voltmeter between the tube cap of the klystron to the right, and ground. This voltage will read between approximately -80 and -240 volts, depending on the setting of the **FO PEAKING ADJ**. If the +300 volts does not appear, the protective lamp (*I-2* in *Figure 8*) should be removed from its socket and checked for continuity. If the lamp is continuous it should be re-inserted in its socket and the tubes in the power supply checked. If the lamp is not a continuous circuit, each klystron should be removed from its socket, and a continuity check made between shell and the cathode pin. A short indicates a defective tube. Replace klystron and protective lamp. If no short is found in the klystrons, the bypass condenser *C-11* should be checked.

Occasionally the fibre grommet will break loose from the wave guide allowing the klystron to short out. This may be remedied by fastening the the grommet to the wave guide with a good grade of acetate cement. Care should be taken not to push the klystron too far into the wave guide as it may short out to the bottom.

C. CRYSTAL HANDLING.

1. **CRYSTAL REMOVAL.** The crystal detector, *D-1* in *Figure 8*, is inserted in a chuck in the waveguide toward the left rear of the panel near the **HIGH** and **LOW** output connectors. To remove the crystal, loosen the thumb screw and raise the crystal by grasping the crystal flange with a pair of diagonal cutters and lifting. To replace, insert the crystal gently into the chuck with tip connection down. Rock crystal from side to side while pressing down gently. When firmly seated all the way in, tighten the screw by hand.

2. **CRYSTAL TESTING.** To determine if crystal *D-1* is defective, check the resistance between the connecting tip and flange with a standard ohmmeter set on the RX 100 scale. Note resistance. Reverse polarity of leads from the ohmmeter at the crystal and note this resistance. One of the two resistance readings should be approximately 200 ohms and the other above 5000 ohms. The high resistance figure on a bad crystal will be low, and, in the case of a completely defective crystal, approximately equal to the low resistance value; or, sometimes both resistances will be high.

3. **CRYSTAL PROTECTION.** *IMPORTANT*

a. The chassis under test and other equipment used should be bonded to the chassis of the **MEGA-SWEEP** before the RF output cable is used. This bond should be maintained throughout the test. Do not depend on the shield of the RF cable for this connection. Test chassis are frequently above ground potential, and currents can be passed through the detector if the hot side of the RF cable touches the chassis before a ground is made.

b. For **MEGA-SWEEP** applications in a frequency range above 15 Mc, a 100$\mu\mu$f condenser should be used in series with the "hot side" of the RF cable at the test circuit. Tape the exposed portions of the connection between the cable and the series condenser.

c. Avoid connection of the RF cable to any point on which a potential exists.

d. Do not use auxiliary marker equipment in parallel with the **MEGA-SWEEP** output if the marker output levels are greater than 2.0 volts.

Careful attention to the details itemized above will reduce crystal detector failures to a great degree.

D. KLYSTRON REPLACEMENT.

The two klystrons, *V-4 & V-5*, are located in a shield box attached to the right rear of the panel. To replace klystrons, remove the two screws at the top of the shield box and remove the top. Note that the metal shells of the klystrons are at +300 volts; the power switch must always be turned off before touching them. The variable klystron, *V-5*, is at the left, and the fixed klystron, *V-4*, is at the right when viewed from the front panel. To replace either klystron, remove the top cap connection, then grasp the tuning control knob and draw the shaft, with its insulating coupling, toward the front panel, at the same time rocking the tube backward slightly to disengage the tuning shaft nut from the coupling. Then withdraw the tube from its socket. After replacing a tube, push the tuning knob shaft back so that the insulating coupling engages the square nut on the cavity-tuning screw.

After replacing either klystron, go completely through the procedure given in Section III to get both tubes in their proper operating frequency range. If the VO was replaced, the dial calibration is almost certain to be affected, even though the frequency settings are properly made, for the various klystrons do not all have the same tuning curve. If the dial does not come satisfactorily close to the actual frequency curve resulting from the new klystron, a new calibration will have to be made. After replacing the dial, the following procedure should be followed:

1. **FREQUENCY STANDARDS.** In order to determine the location of the various frequency calibration points on the dial, some sort of frequency standard which gives the true output frequency will be required. The internal

absorption-type **FREQUENCY METER** can, of course, be used, taking frequency differences as described in Section IV, B-3. Self-oscillating types of frequency standard are also entirely suitable for this purpose, and most of them are somewhat simpler and easier to use. Therefore, they should be employed, if available. Any signal generator, or even a grid-dip meter, if accurately calibrated, is suitable. It should be coupled either conductively or inductively to the external detector, and the resultant wave, which will show any beats between the standard and the output of the **111-A**, as viewed on the scope. The widest possible sweep will prove to be the most rapid and convenient method of finding and showing the beat, and since it also permits checking the calibration of the **SWEEP WIDTH** control with the same setup, it is the preferred method. Harmonics of the standard will give useful markers if enough amplitude (say 0.5 volt) from the standard is available at the detector box. For example, with a standard set at 200 Mc, beats at 100, 200, 300, 400, 600, and 800 Mc are useful, and this is a spectrum of standard frequencies quite sufficient for the purpose, although, if desired, other frequencies can be obtained by setting the standard at other points.

2. SELECTION OF KLYSTRONS & DIAL CALIBRATION.

a. Normally, selection will be done at the factory, the replacement klystrons being delivered already selected and marked with their proper position (VO or FO) and the wavemeter settings at which the FO should operate in each of the two output frequency ranges. An engraved dial will also be sent with the klystrons. Orders for replacement klystrons should specify the serial number of the particular instrument in which they will be used, and the position (FO or VO) of the tube.

Factory selected replacement tubes, when properly inserted into the instrument, should operate properly and respond to all of the frequency setting and other procedures given in Section III. However, due to slight differences in the instruments, completely satisfactory operation may not be obtained at the wavemeter settings recommended on the replacement tubes, and usually better operation will result if settings are changed slightly.

b. For this reason, and to assist the user to a better understanding of the operation and adjustment of the **MEGA-SWEEP**, the following complete selection, adjustment, and recalibration procedures are given. It is not necessary in all cases to perform every step, though certainly nothing will be harmed by doing so. The user should select from the complete procedure those steps which will permit him to accomplish the result he is after, whether a simple dial recalibration or a complete setup including selection of suitable tubes from among any which he may happen to have on hand.

E. INSTALLATION OF FACTORY ADJUSTED KLYSTRONS.

1. Turn the coarse frequency control on the front panel to its extreme counterclockwise position (tube out of socket). Insert the #5 klystron in its socket, taking care not to disturb the repeller nut of the tube. This nut is preadjusted at the factory.

2. Engage the klystron repeller nut with the coarse frequency control.

3. Attach the dial which accompanies the #5 klystron to the shaft protruding from the front panel, setting the line on the dial to coincide with the indicating line on the front panel.

4. Loosen the stops on the #4 klystron. Set the #4 klystron so that the wavemeter will produce a dip in the metered output of the #4 klystron at the number indicated on the #5 klystron. This will be at around zero on the wavemeter. Set one of the stops at this point.

5. Set the dial of the #5 klystron so that it reads at zero Mc. Connect the output of the sweeping oscillator directly into vertical plates of an oscilloscope. Connect the sweep output terminals to the horizontal terminals of the oscilloscope.

6. Turn the #4 klystron in the VHF direction until zero beat is displayed on the oscilloscope. It will be necessary to readjust the #4 oscillator peaking control to restore oscillation.

7. Set the second stop of the #4 klystron at this point.

F. INSTALLATION OF STOCK KLYSTRONS.

1. SELECTION OF KLYSTRONS. In the **111-A**, the fixed oscillator (FO) must operate at either of two different frequencies. Its selection, therefore, is more critical than the VO, for this VO operates over a smaller frequency range. The FO requires a klystron that will operate stably and with good output at frequencies in the vicinity of 00 and 1000 on the **FREQUENCY METER**.

With the klystrons installed and fully warmed up, adjust the cavity of the FO by means of the panel control marked **FIXED OSC TUNER** until it is oscillating at 00 on the **FREQUENCY METER** scale. This is the extreme low-frequency end of its range and requires that the external tuner bows be widely spread, thus forcing the cavity grids close together. The output amplitude in most tubes varies rather widely and rapidly with cavity tuning in this region, and it may happen that a frequency giving a scale reading of 00 on the wavemeter falls at a point of low output. In this case, it is permissible to change the frequency slightly, but preferably not more than two full turns (200 divisions) away from 00. The repeller voltage should be set, by means of the panel control marked **FIXED OSC PEAKING ADJ**, for maximum output each time the cavity tuning is adjusted. Make this adjustment with the **SWEEP** switch set at **NO BL** so that operation will always be on the proper side of the blanking wave when this is switched on. Observation of output amplitude can either be on an oscilloscope showing the rectified output of the **111-A**, or on the panel crystal-current meter, holding the **PUSH** switch operated so as to read only the current due to the FO. A satisfactory klystron should give a reading of 30 to 50 microamperes, with 20 as about the lower rejection limit.

When satisfactory operating conditions have been obtained, record the **FREQUENCY METER** scale setting which results; always set the FO to this frequency when operating the **111-A** in its high frequency output range (400 to 950 Mc).

One more setting for the FO must be determined, that at which it will always be operated to obtain the low frequency output range (10 to 500 Mc). On this range the FO operates just 400 Mc higher in frequency, that is, at about the middle (1000) of the wavemeter scale. If the wavemeter is to be used in making this adjustment, compute the scale reading which is just 400 Mc higher in frequency than the high range setting arrived at above. (If the high range setting was at 00 on the scale, the low range setting will be 920.) Tune the FO until its wavemeter dip comes at this new setting; its cavity tuner shaft will have to be turned about one full turn (counterclockwise), or perhaps a little more, to accomplish this. Track the repeller voltage for maximum output while tuning, using the **FO PEAKING ADJ**. If satisfactory output is obtained here also, the tube will do for use as the FO, and its low range wavemeter scale setting also should be recorded for future reference.

2. THE VARIABLE KLYSTRON (VO). The requirements for this tube are that it must tune over a range of at least 550 to 600 Mc, starting from the middle of its tuning range (about 1000 on the wavemeter) and going up in frequency to 2000 or 2100 on the wavemeter. Tuning must be smooth and continuous, without sudden jumps either in the output or the required repeller voltage. Such effects indicate sudden shifts of frequency which would prevent satisfactory repeller voltage tracking and dial calibration. Tubes showing them should be rejected for use in the VO position, although many such tubes will be usable as the FO if care is taken in choosing the two operating frequencies. As with the FO, frequency setting of the VO can be done without the use of any external equipment, the self-contained wavemeter being the standard and the crystal-current being used to indicate resonance. However, many effects other than merely the ability to tune and give output are of interest in the VO, and such effects are much more evident and unmistakeable when the output is viewed on an oscilloscope. Also, the small frequency differences which will be of interest in making the dial calibration are much more readily and accurately determined by the use of external markers. Therefore, in the procedure that follows, it is assumed that the output voltage of the **111-A** is being rectified by a suitable detector, that an external source is being coupled into this detector to produce marker beats, and that the rectified output of the detector is being viewed on a scope.

Best results are obtained with a wide sweep on the VO repeller, so wide that the repeller is swept entirely through one of its modes, showing the region of no output on each

side. Set the SWEEP switch at WIDE, the SWEEP WIDTH control at maximum, and adjust the internal SWEEP setting potentiometer, *R-11*, toward its maximum end until the entire repeller mode is displayed. There is adequate reserve of sweep voltage to permit this.

Now adjust the VO cavity tuning, by means of the control knob on the dial gear box, so that it is at its lowest operating frequency, that which gives an output of 400 Mc on the high range and 0 Mc on the low range. This will come at the higher of the two FO scale settings, that which falls at about 1000 on the wavemeter scale. If the FO is at that point also, the region of zero beat will be seen in the middle of the sweep. Center the VO repeller mode on the swept trace by means of the VO PEAKING ADJ.

3. SETTING THE DIAL MECHANISM. The VO is now at that operating frequency which gives an output frequency of 0 Mc on the low range and 400 Mc on the high. As far as the stops of the dial mechanism are concerned, this setting must come almost at the extreme clockwise limit of rotation; the rotation stops are determined by the tracking potentiometer, *R-29*, which is driven from the dial shaft through 1:1 ratio gearing. To adjust for the correct relationship, leave the VO set at the correct frequency, switch off the power, and disengage the insulating shaft coupling from the tuning screw of the VO klystron, taking care not to change the setting of this screw. Rotate the dial mechanism all the way clockwise to its motion stop, but do not force the stop. Ignore the dial reading. Re-engage the shaft with the nut on the tuning screw at the very next possible engagement relationship counterclockwise from the stop. Switch on, warm up, and check to see that zero beat is still in the center of the sweep. If not, the setting of the klystron was disturbed and the adjustment should be repeated more carefully.

The tuning of the VO cavity and the angular rotation range of the tracking potentiometer, *R-29*, are now in correct relationship to each other, the cavity reaching its lowest tuning frequency at the time that the tracking potentiometer is at its lowest value of included resistance. Loosen the dial setscrew and set the dial at 0 (400). Operate the tuning mechanism over its full range three or four times to stabilize the action of the klystron tuning bows, ending the operation by going all the way clockwise to the stop past zero, then upscale again to the zero mark. The zero beat region should again be in the center of the sweep; if not, readjust the setting and then the dial.

Operate the dial slowly over its range, bringing the various frequency markers due to the beats with the external standard successively to the center of the sweep, and noting the dial reading obtained for each. If they do not fall acceptably close to their proper positions, cement a new blank dial over the old one and mark the various frequency points on it, each setting being made with the marker brought to the exact center of the swept region. As a minimum, the 100, 200, 300, 400, and 500 Mc points should be located for the low range, together with any others desired for which marker frequencies are available. The high frequency output scale is of course the same as the low as far as the location of the points is concerned; each is labelled just 400 Mc higher than on the low range.

G. REPELLER VOLTAGE TRACKING.

1. The repeller voltage of the FO is not tracked automatically, and because of this, the panel FO PEAKING ADJ should be readjusted whenever the frequency of this oscillator is shifted. The adjustment should of course be made with the SWEEP switch set at NO BL in order to be sure of operating on the correct side of the blanking wave. The screwdriver-adjusted control which sets the blanking-shift increment is located behind the upper right corner of the front panel and is labelled BLANK. To set it, have the SWEEP switch set at WIDE; adjust the VO tuning dial to bring any convenient frequency marker into the center of the sweep. Switch to NAR; the marker should stay in the middle of the sweep, becoming somewhat broader. Then switch to NO BL; the marker should still remain in the middle of the sweep. If it does not, adjust the BLANK control to bring it there. This adjustment should always be made following any tube or circuit changes in the sweep circuit portion of the instrument.

2. The repeller voltage for the VO is tracked automatically with the tuning dial for greater ease and convenience of use of the instrument. The repeller is at its minimum negative voltage, about -120 volts for most klystrons, when the dial is at 0 frequency. As the dial

is rotated toward 500 Mc, the repeller must rise to a maximum of about 140 volts negative, depending upon the particular klystron being used. But, the required rise of voltage is not quite linear with angular rotation of the dial, and consequently, provision has been made to shape the voltage curve to fit the requirements of the klystron. There are two screwdriver-set controls in back of the panel, and together with the front panel control marked **VO PEAKING ADJ**, these three controls permit adjusting the voltage rise curve to fit the klystron curve exactly at any three points in the range. The slight departures from perfect tracking that may remain are taken care of by slight readjustments of the panel control when necessary.

3. The complete tracking operation for the variable oscillator is as follows:

a. Set dial at 400, adjust **VAR OSC PEAKING ADJ** for maximum microammeter reading or for maximum RF output.

b. Set dial at 700, adjust internal SLOPE potentiometer and maximize as above.

c. Set dial at 900, adjust internal SHAPE potentiometer and maximize as above.

d. Repeat above procedure, touching up, when necessary.

e. Return to 0 and then scan the entire tuning range to see how good a match you have. It may be necessary to cover steps *b* and *c* a few times to get the best result. These two controls interlock in their effects to some extent; the adjustment of one tending to cancel part of what was done to the other, and it may be useful to overcontrol, that is, to go too far when setting these controls, for the first few settings.

H. SETTING SWEEP WIDTH.

The purpose of this adjustment is to set the internal potentiometer, *R-11*, located on the sweep circuit chassis and marked SWEEP, so that the panel calibrations of the **SWEEP WIDTH** control are correct. Use a movable marker, either the internal wavemeter or the more convenient externally-supplied movable birdie marker from a signal generator. With the **SWEEP WIDTH** control set at a maximum and the **SWEEP** switch at **WIDE**, adjust the internal potentiometer so that the sweep width is exactly 40 Mc, as indicated by the fact that the external frequency standard must be moved just that far in order to make the marker traverse the full width of the sweep. Check the **NAR** setting; the sweep width here should be about 15 Mc at maximum setting of the panel control. If it is not close enough to 15 Mc, the sweep can be adjusted by changing the value of *R-12*.

I. DETECTOR BOX.

A most useful accessory for service and maintenance tests on the **111-A**, as well as for many of the actual applications of the instruments to electronic test and development work, is a detector or rectifier box. There are many variations of this accessory which will make it suitable for various types of work; for example, it can be arranged to terminate the cable to which it is connected, or it can be used as a bridging device. Multiple inputs can be provided for use as a mixing or heterodyning device, or markers can be coupled in, etc. These variations will occur to the user; the simplest, basic circuit is that of a terminating rectifier which absorbs the entire output of the **111-A** and produces a varying d-c voltage proportional to the RF output of the **MEGA-SWEEP**. This is the type referred to in the various tests and adjustments of the preceding section, and its circuit, constants, and a suggestion as to its mechanical design is given in *Figure 5*. The input coupling capacitor is required to isolate the large d-c component which appears on the output connector of the **111-A** due to rectification of the X-Band oscillators by the internal mixer crystal.

If the detector box is carefully laid out and constructed with low-inductance capacitors and small wiring loops, it will be useful over the entire output frequency range of the **111-A**.

J. POWER SUPPLY UNIT.

The power unit includes two separate electronically regulated voltage sources, one of positive 300 volts for the accelerating voltages of the klystrons and for the sweep circuit tubes, the other a negative 300 volts supply for the repeller circuits and for bias. The positive supply is conventional in design, employing a VR-150 glow tube as the reference voltage standard, a three-stage

d-c amplifier, and a 6Y6 as the series control tube. The negative supply uses only a single 6AC7 as a series control tube, being placed in the circuit at a point where its grid will be approximately at zero potential (actually a few volts negative). The grid voltage is determined by equating the output voltage of the negative supply to that of the positive lead, by feeding this grid through two equal resistors. Thus, the tube will set itself at that value of current through itself and will produce this equality of output voltage. In other words, the positive supply is used as a reference to determine the negative output voltage. This simple circuit is adequate to give good performance because of the low and constant current drain on the negative 300 volt lead.

Trouble shooting procedures in the power unit should follow conventional practices for this class of equipment. Sufficient normal operating voltage values are indicated on the power unit schematic circuit diagram to permit checking for abnormal conditions, faulty components, etc.

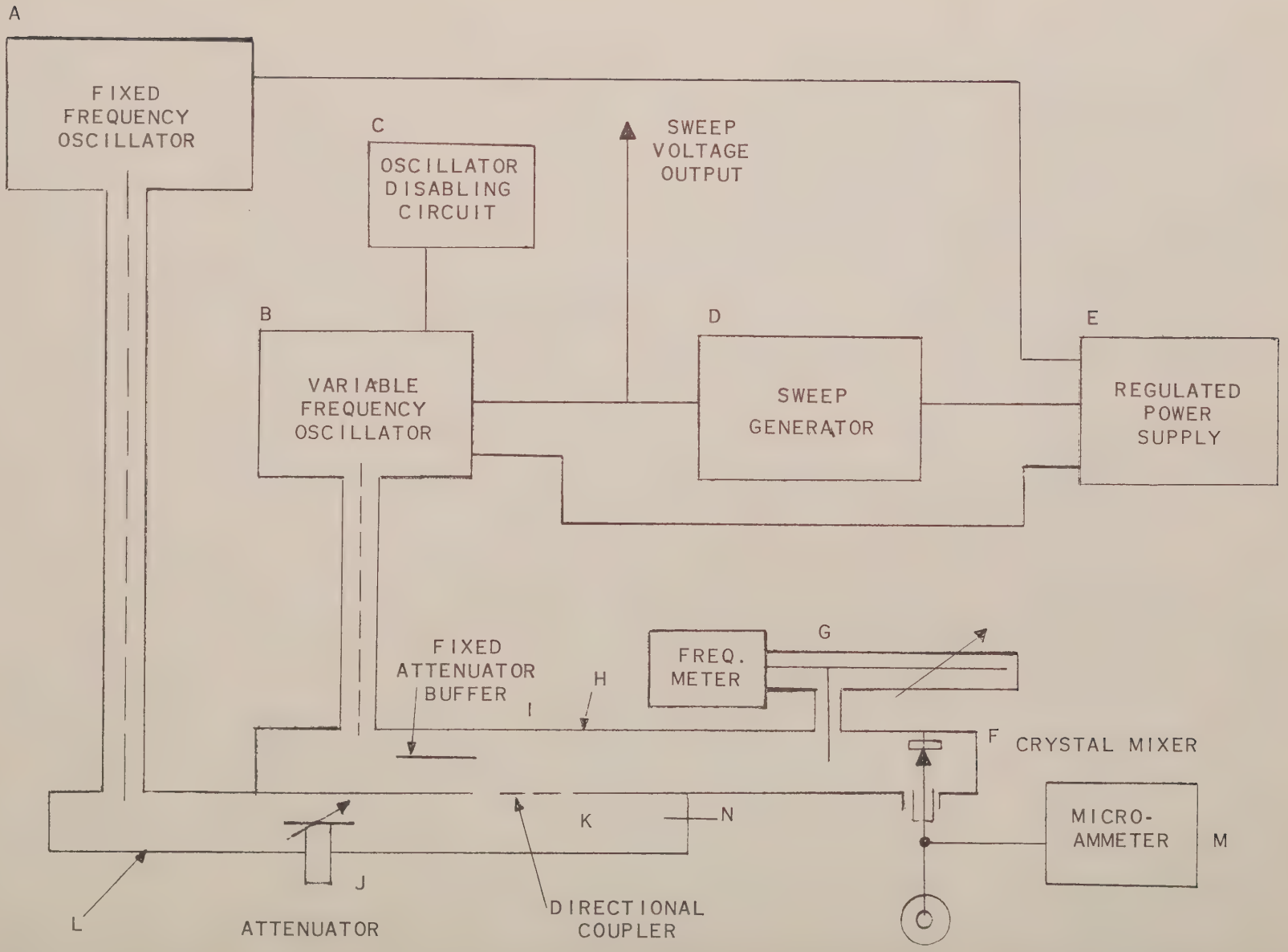


Figure 2, Block Diagram

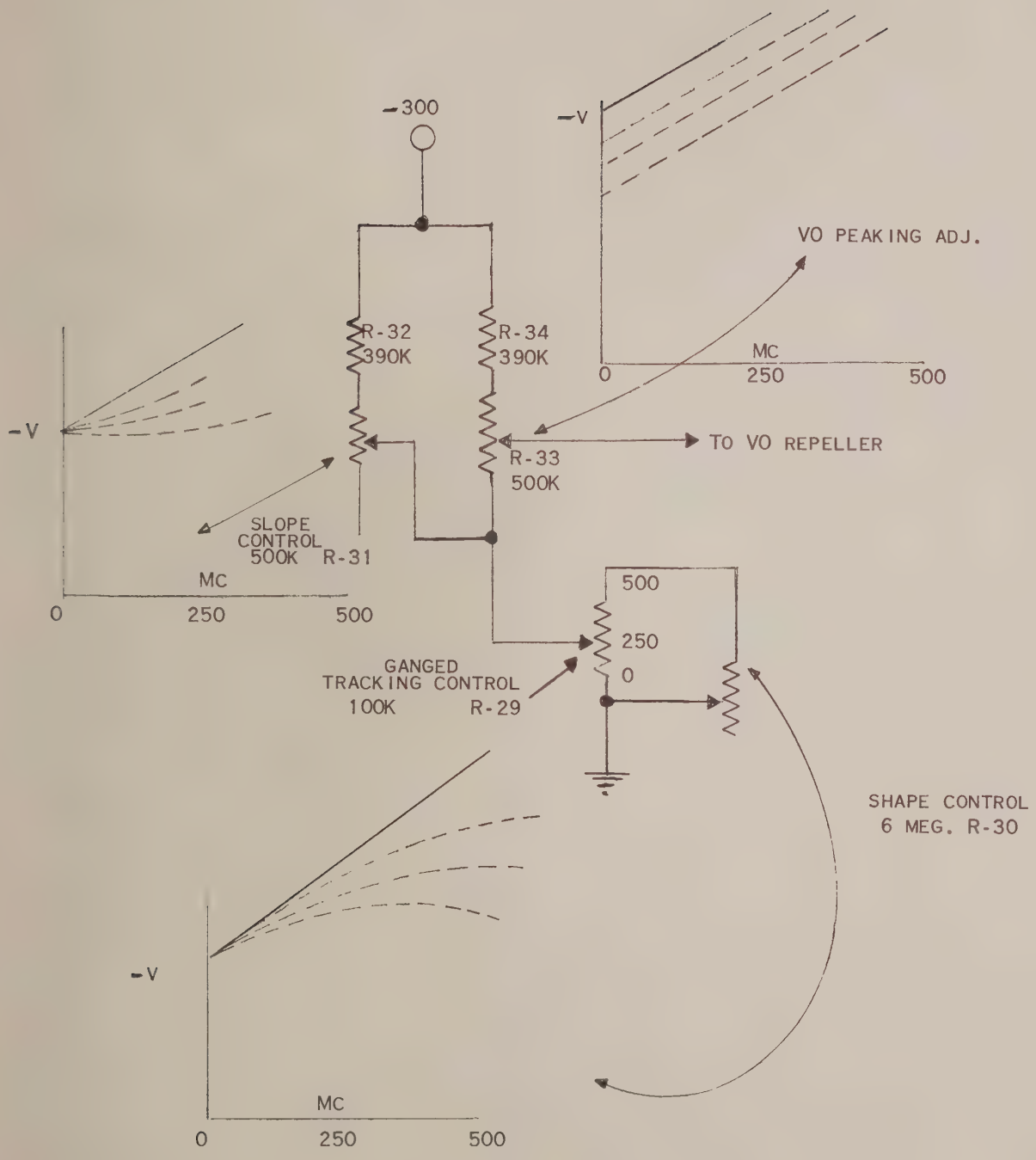


Figure 3. Effects of Controls

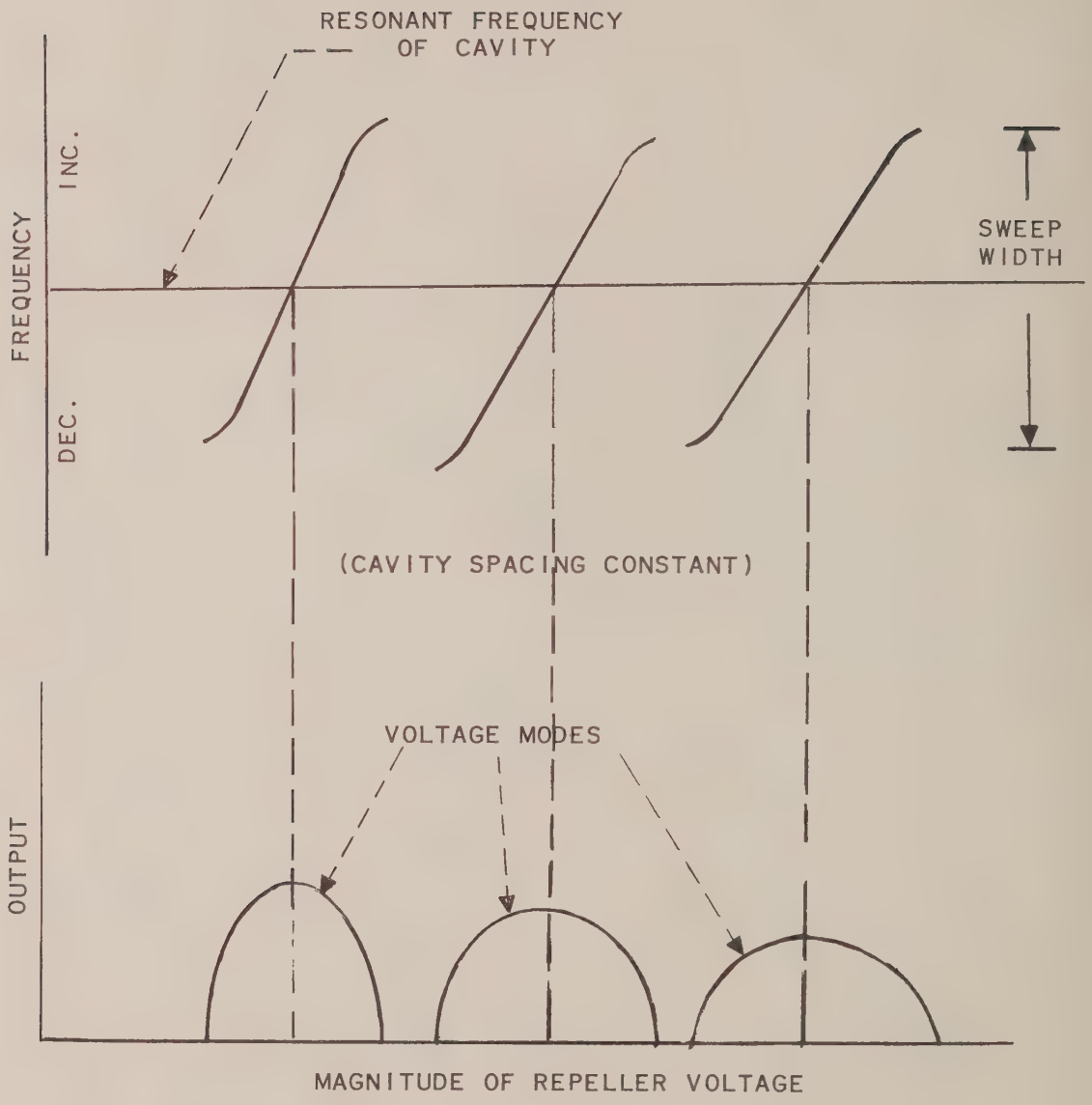
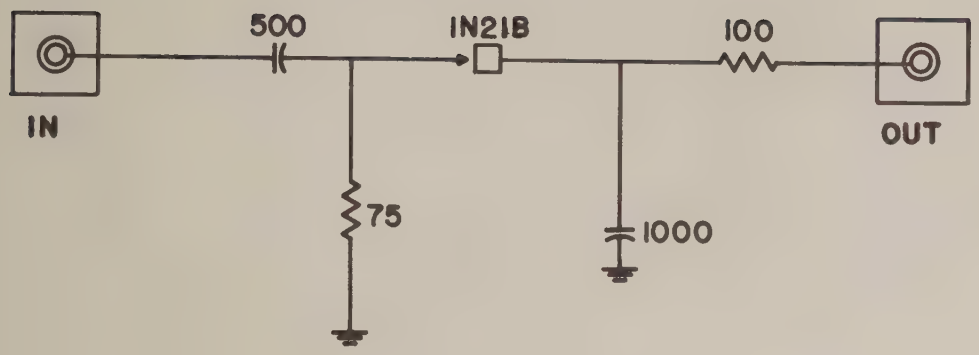
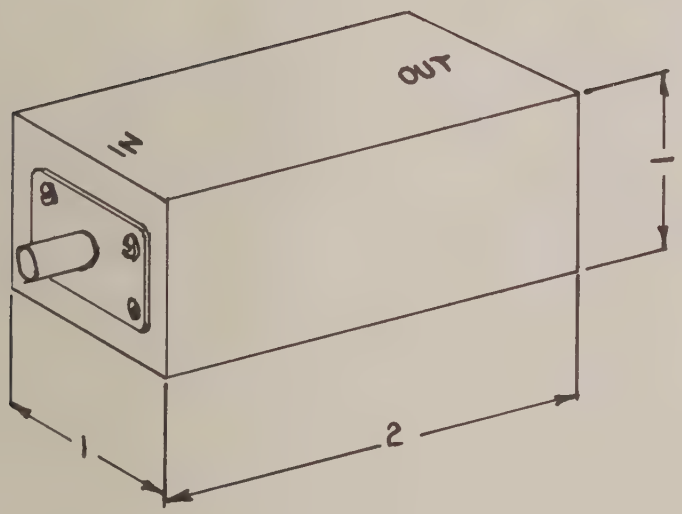


Figure 4, Klystron Characteristics





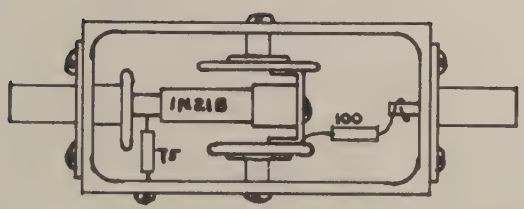


Figure 5, Detector Box

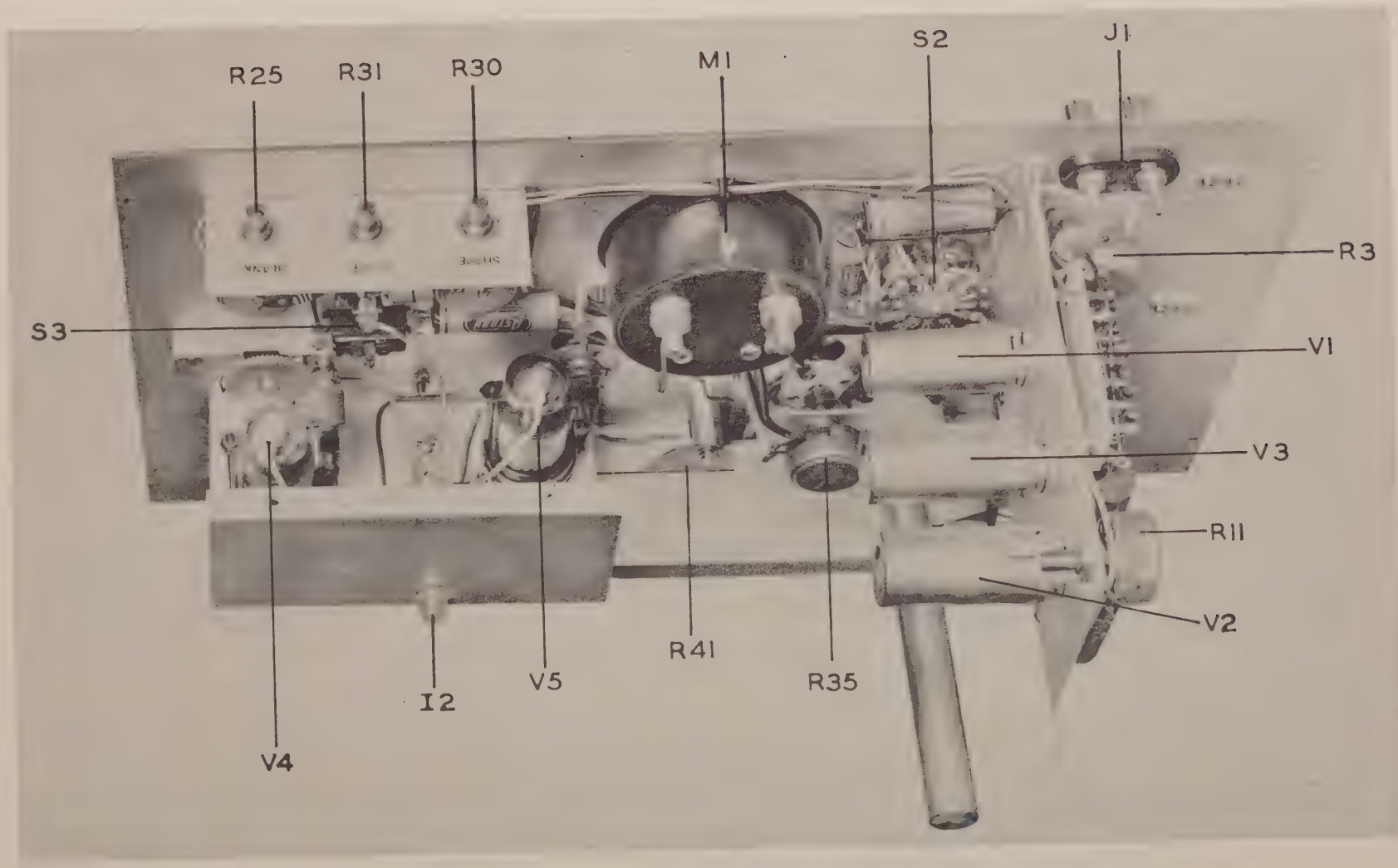


Figure 6, Component Location (upright position).

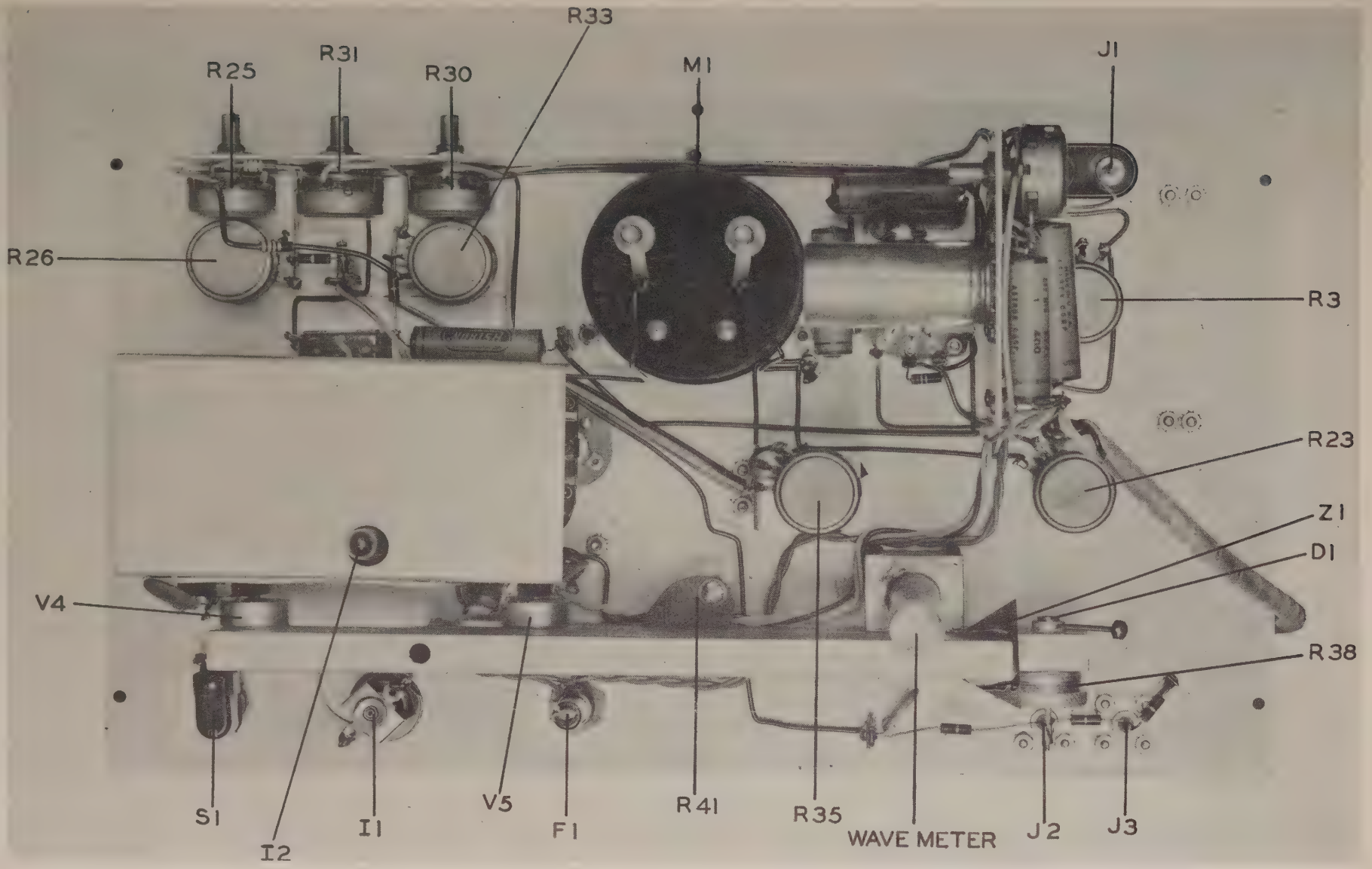


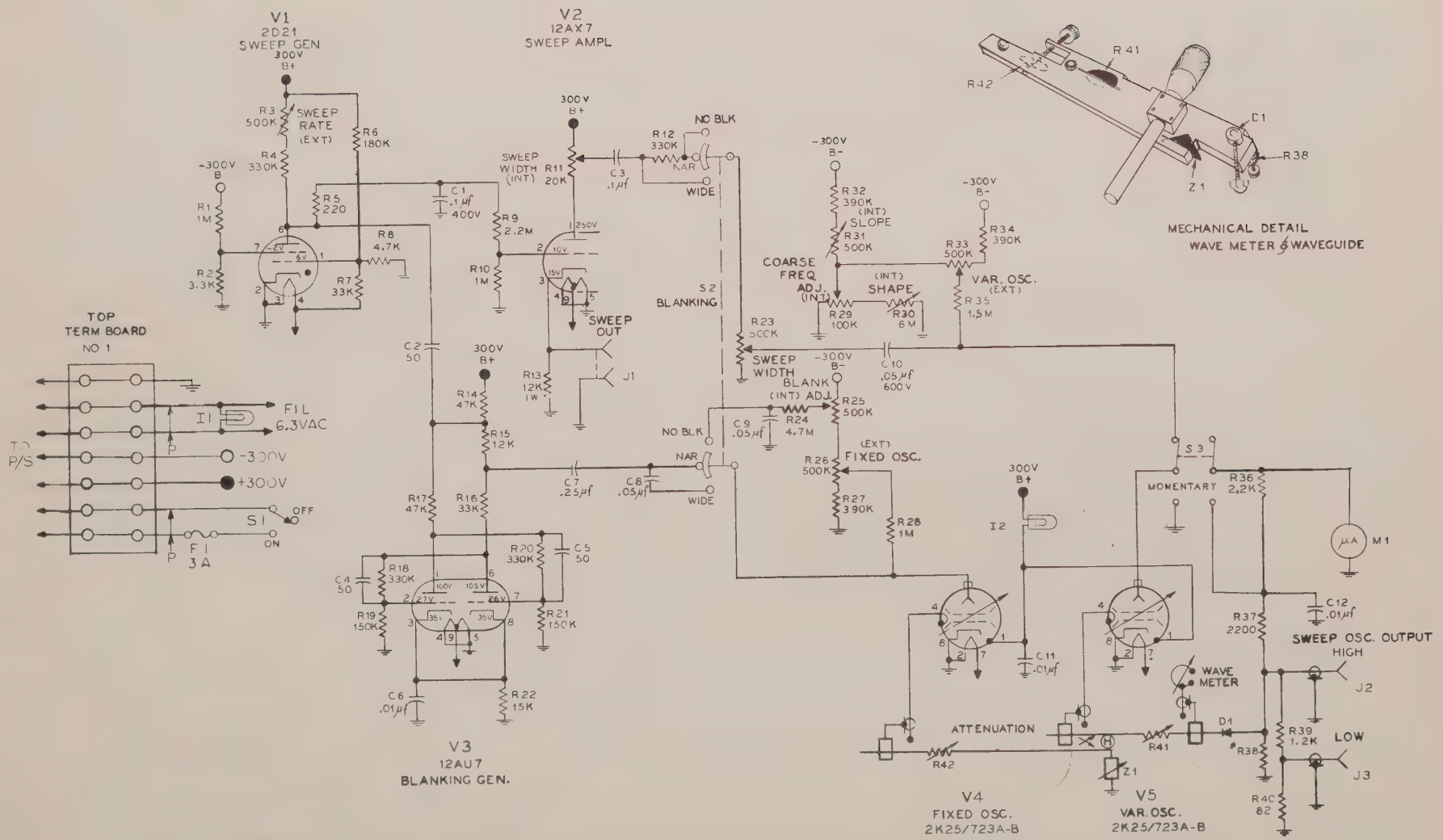
Figure 7, Component Location (face down position).

SECTION VI
PARTS LIST

A. III-A MEGA-SWEEP PANEL.

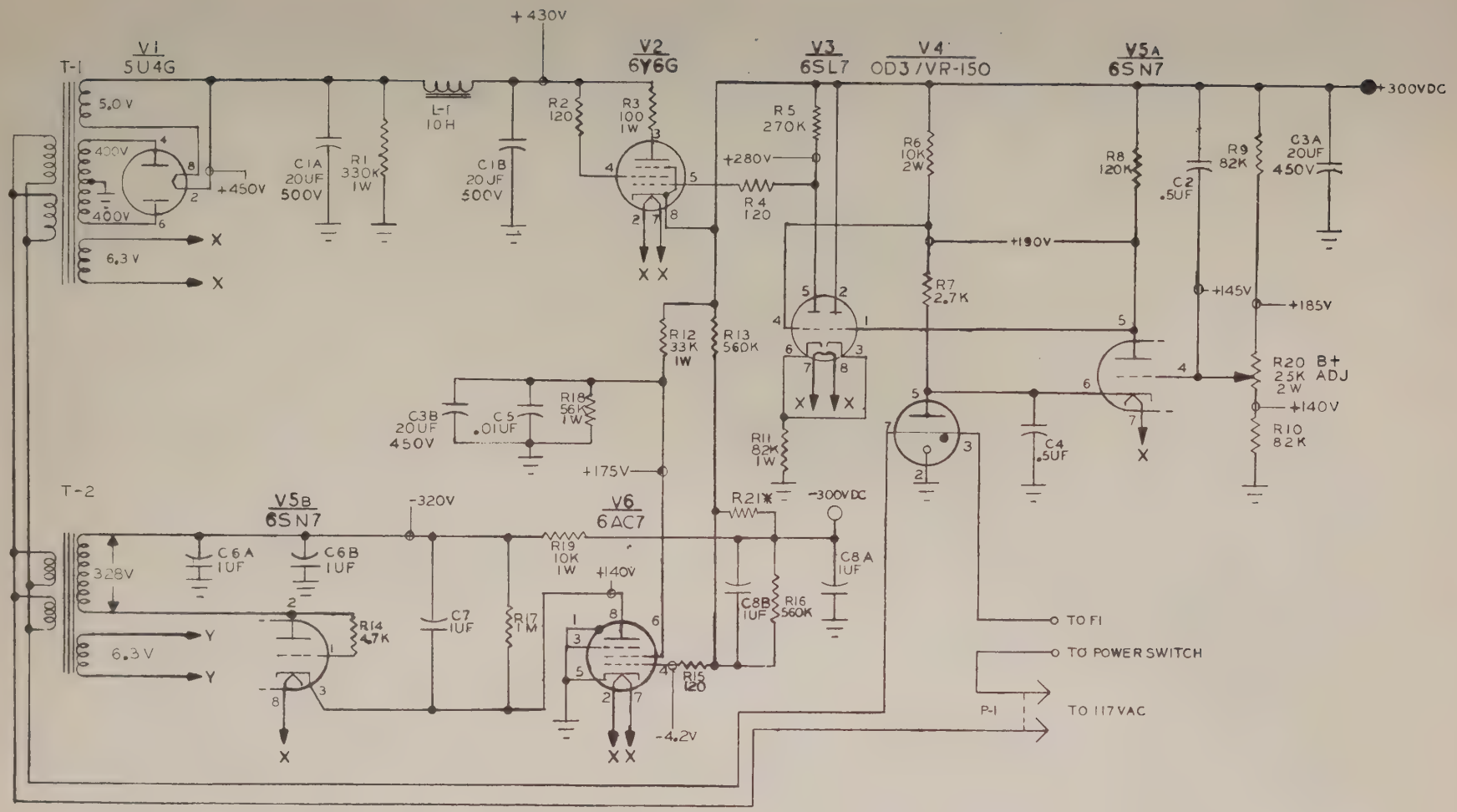
DWG. SYMBOL NO.	DESCRIPTION	KAY PART NO.
	Capacitors: (ALL CAPACITORS IN $\mu\mu F$, 500 VOLTS UNLESS OTHERWISE SPECIFIED.)	
C-1	0.1μF, 400V, MYLAR-PAPER	6899-2
C-2	50, CERAMIC (TUBULAR)	6361-15
C-3	0.1μF, 400V, MYLAR-PAPER	6899-2
C-4	50, CERAMIC (TUBULAR)	6361-15
C-5	50, CERAMIC (TUBULAR)	6361-15
C-6	0.01μF, CERAMIC DISC	6360-6
C-7	0.25μF, 400V, MYLAR-PAPER	6899-3
C-8	0.05μF, 400V, MYLAR-PAPER	6899-6
C-9	0.05μF, 400V, MYLAR-PAPER	6899-6
C-10	0.05μF, 400V, MYLAR-PAPER	6899-6
C-11	0.01μF, CERAMIC DISC	6360-6
C-12	0.01μF, CERAMIC DISC	6360-6
D-1	1N21B, CRYSTAL DIODE	6357-16
F-1	FUSE, 3 AMP, 250V	245
I-1	LIGHT INDICATOR #44	249
I-2	LIGHT INDICATOR #44	249
J-1	BINDING POST	257
J-2	CONNECTOR UG-185/U	204
J-3	CONNECTOR UG-185/U	204
M-1	METER, 0-200 DC UA	324
	Resistors: (UNLESS OTHERWISE INDICATED, ALL COMPONENTS ARE FIXED COMPOSITION, ½ WATT, 10% TOLERANCE RESISTORS.)	
R-1	1 M	1051-E
R-2	3.3 K	3321-E
R-3	500 K, 2 WATT POT, VARIABLE	126
R-4	330 K	3341-E
R-5	220	2211-E
R-6	180 K	1841-E
R-7	33 K	3331-E
R-8	4.7 K	4721-E
R-9	2.2 M	2251-E
R-10	1 M	1051-E
R-11	20 K, 2 WATT POT, VARIABLE	78
R-12	330 K	3341-E
R-13	12 K, 1 WATT	1231-E
R-14	47 K	4731-E
R-15	12 K	1231-E
R-16	33 K	3331-E
R-17	47 K	4731-E
R-18	330 K	3341-E
R-19	150 K	1541-E
R-20	330 K	3341-E
R-21	150 K	1541-E
R-22	15 K	1531-E
R-23	500 K, 2 WATT POT, VARIABLE	126
R-24	4.7 M	4751-E
R-25	500 K, 2 WATT POT, VARIABLE	126
R-26	500 K, 2 WATT POT, VARIABLE	126
R-27	390 K	3941-E
R-28	1 M	1051-E
R-29	100 K, 2 WATT POT, VARIABLE	121
R-30	6 M, 2 WATT POT, VARIABLE	138
R-31	500 K, 2 WATT POT, VARIABLE	126
R-32	390 K	3941-E

DWG. SYMBOL NO.	DESCRIPTION	KAY PART NO.
R-33	500 K, 2 WATT POT, VARIABLE	126
R-34	390 K	3941-E
R-35	1.5 M	1551-E
R-36	2.2 K	2221-E
R-37	2.2 K	2221-E
R-38	CARBON RESISTANCE CARD	1638
R-39	1.2 K	1221-E
R-40	82	8201-E
R-41	CARBON RESISTANCE CARD	58
R-42	CARBON RESISTANCE CARD	59
S-1	SWITCH, TOGGLE, SPST	255-C
S-2	SWITCH, WAFER, ROTARY	1540
S-3	SWITCH, TOGGLE, DPDT	256-C
V-1	TUBE, 2D21	2D21
V-2	TUBE, 12AX7	12AX7
V-3	TUBE, 12AU7	12AU7
V-4	TUBE, 2K25/723A-B	2K25/723A-B
V-5	TUBE, 2K25/723A-B	2K25/723A-B
Z-1	CARBON RESISTANCE CARD	52



NOTE
UNLESS INDICATED OTHERWISE
ALL RESISTANCES IN OHMS
ALL CAPACITANCES IN $\mu\mu f$
* INTERNAL RESISTANCE VARIES FROM UNIT TO UNIT

Figure 8, Schematic Diagram, 111-A Mega-Sweep, KC-2217-F



* SELECTED — MAY BE OMITTED

Figure 9, Power Supply Schematic, KB-2106-F

B. POWER SUPPLY PARTS LIST.

DWG. SYMBOL NO.	DESCRIPTION	KAY PART NO.
C-1 A & B	20/20μF, 500V, ELECTROLYTIC	6355-11
C-2	0.5μF, 600V, BATHTUB	325
C-3 A & B	20/20μF, 450V, ELECTROLYTIC	331
C-4	0.5μF, 600V, BATHTUB	325
C-5	0.01μF, 500V, CERAMIC DISC	6360-6
C-6 A & B	1/1μF, 600V, BATHTUB	1748
C-7	1μF, 600V, BATHTUB	326
C-8 A & B	1/1μF, 600V, BATHTUB	1748
L-1	CHOKE, 10 HY	323B
P-1	AC LINE CORD	328
R-1	330 K, 1 WATT, 10% TOLERANCE	3341-G
R-2	120, ½ WATT, 10% TOLERANCE	1211-E
R-3	100, 1 WATT, 10% TOLERANCE	1011-G
R-4	120, ½ WATT, 10% TOLERANCE	1211-E
R-5	270 K, ½ WATT, 10% TOLERANCE	2741-E
R-6	10 K, 2 WATT, 10% TOLERANCE	1031-H
R-7	2.7 K, ½ WATT, 10% TOLERANCE	2721-E
R-8	120 K, ½ WATT, 10% TOLERANCE	1241-E
R-9	82 K, ½ WATT, 10% TOLERANCE	8231-E
R-10	82 K, ½ WATT, 10% TOLERANCE	8231-E
R-11	82 K, 1 WATT, 10% TOLERANCE	8231-C
R-12	33 K, 1 WATT, 10% TOLERANCE	3331-G
R-13	560 K, ½ WATT, 10% TOLERANCE	5641-E
R-14	4.7 K, ½ WATT, 10% TOLERANCE	4721-E
R-15	120, ½ WATT, 10% TOLERANCE	1211-E
R-16	560 K, ½ WATT, 10% TOLERANCE	5641-E
R-17	1 M, ½ WATT, 10% TOLERANCE	1051-E
R-18	56 K, 1 WATT, 10% TOLERANCE	5631-G
R-19	10 K, 1 WATT, 10% TOLERANCE	1031-G
R-20	25 K, 2 WATT POT, VARIABLE	114
R-21	FACTORY SELECTED	
T-1	TRANSFORMER, POWER	321
T-2	TRANSFORMER, POWER	319
V-1	TUBE, 5U4	5U4
V-2	TUBE, 6Y6	6Y6
V-3	TUBE, 6SL7	6SL7
V-4	TUBE, OD3/VR-150	OD3/VR150
V-5	TUBE, 6SN7	6SN7
V-6	TUBE, 6AC7	6AC7

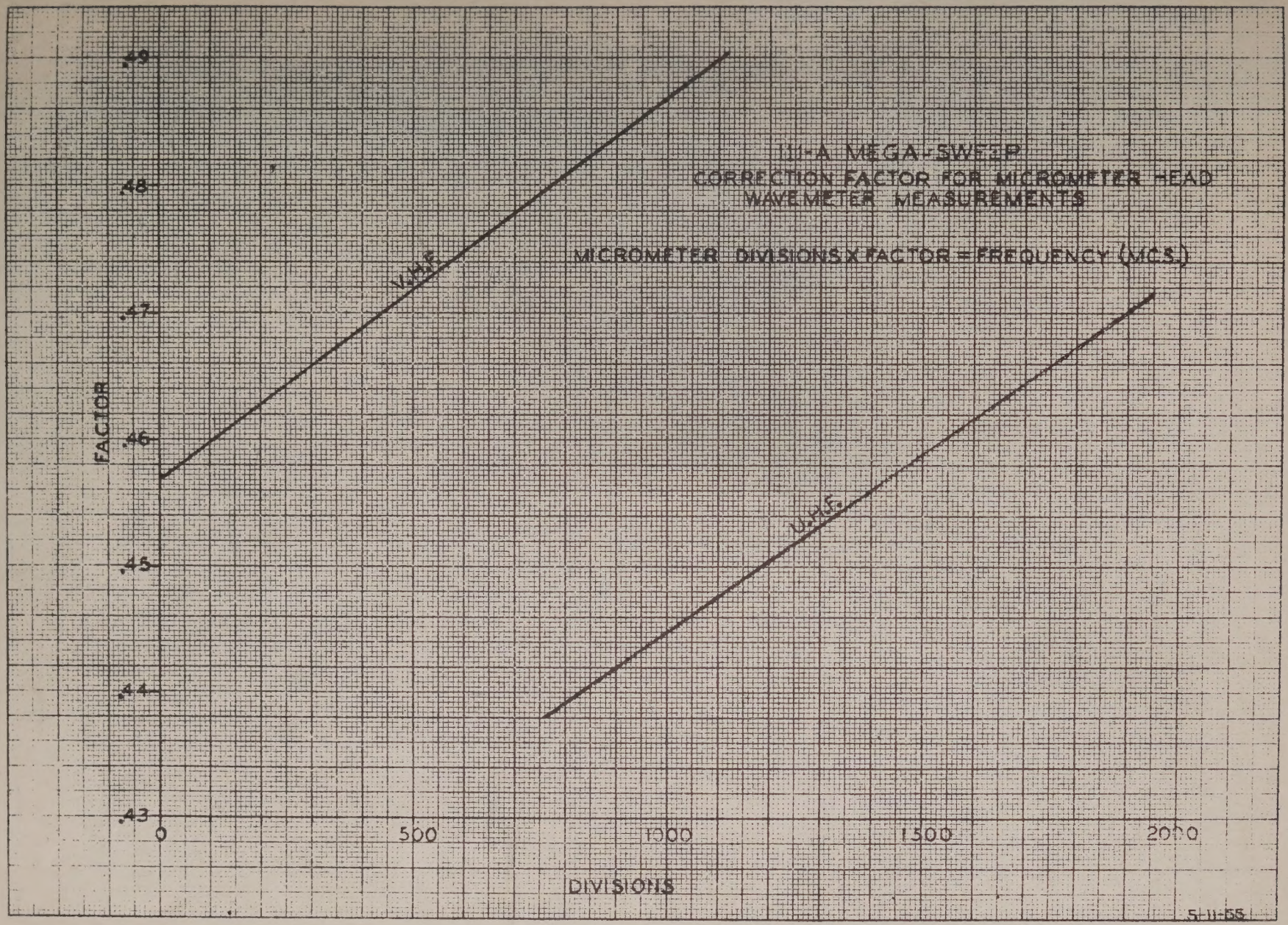


Figure 10, Correction Factor for Micrometer Head Wavemeter Measurements.